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ABSTRACT

This paper contends that efforts at educational reform must focus, above all, on the instructional encounter between teachers and students. The argument is presented in triadic sequence: three basic assumptions about learning, three interrelated models of the instructional process, and three practical approaches to promoting cognitive achievement. The three assumptions are as follows: (1) cognitive activity is inherent and patterned; (2) learning is a goal-oriented cognitive activity; and (3) instruction is an intentional activity where teachers intend to influence students' learning. The three models which synthesize contemporary research on teaching and instructional psychology are as follows: (1) the 6-factor CEDARS model of instruction (content, evaluation data, delivery of task cues, acquisition, retrieval, and setting); (2) the cognitive mediational model of teaching effectiveness; (3) the task-oriented model of student learning. These models are then applied in a discussion of teaching methods that can promote cognitive achievement. These methods include (1) steps toward realizing instructional intentions (gaining attention, clarifying perceptions, maximizing capability, and motivating cognitive work), (2) steps toward facilitating instructional tasks (comprehending initial conditions, comprehending the goal, and having plans for transforming the initial conditions into the goals, and (3) steps toward taking steps (revamping teacher education curricula and encouraging further cognitive research to clarify interactions among the facets of instruction). (TE)

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STEPS TOWARD PROMOTING COGNITIVE ACHIEVEMENTS

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The National Commission on Excellence in Education has issued nothing less than a stark challenge to America. In its report, A Nation at Risk: The Imperative for Educational Reform, the commission asserts unconditionally that if America does not remedy flaws and overcome difficulties in its educational system, then the country's leading place in the world may be forfeit. From my vantage point as an instructional psychologist, all the recommendations made in the report are welcome. But these proposals are, for the most part, global. They need to be analyzed further so they can be put into action. And, the report failed to consider one of the most obvious and most significant aspects of our educational system, namely, teaching. In this paper, I propose several remedies for this shortcoming. My focus is topics that bear directly on what happens when teachers try to teach and when students try to learn from teaching.

I hold that instruction is the fulcrum on which the lever of education rests. There is no doubt that changes need to be made to the educational system--changes such as improving the quality of textbooks, or increasing the time allocated to learning and homework, or selecting better teachers. What teachers and students do in classrooms, however, determines whether other changes to the educational system will have any effect at all. If instruction is flawed or inadequate, no other improvement to education will have fair chance to work. In taking this stance, I do not insinuate that non-instructional aspects of education can remain as they are. My claim is simple: anything that slights or interferes with the effectiveness of moment-to-moment teaching and learning will subvert the aim to improve education.

Let me introduce some central ideas about instruction in the form of an analogy that should have direct relevance to each of you. I presume you are here to learn about how to promote cognitive achievements, and that you expect me to teach you about steps to take in approaching this goal. There is little doubt that, as a group, you enter this lesson with different interests, varying amounts and types of knowledge about the topics I'll address, and all sorts of other differences that may affect how much and how well you learn from my talk. For instance, some of you undoubtedly should have gone to bed earlier than you did to be in top form for today's sessions. Others of you, in your zeal to arrive promptly at this first session, now may be distracted by your stomach's complaints about skipping breakfast or wolfing something of less than home-cooked quality.

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The kinds of differences I've just described clearly influence how well this lesson will work. They are differences over which I have no control. That they affect your achievement only reinforces my point that there must be more teeth in responses to education's woes than merely a "quick fix" that I might attempt in the next hour of teaching. In my role as teacher, however, I can influence to some extent how you think. If it takes thinking on your part to learn, and I assert without proof that it does, then my teaching effectiveness varies in direct proportion to the extent that I can influence your thinking. The question that confronts me, as your teacher for the next hour, is how can I shape what you think about and how you think about it.

Let me foreshadow the rest of this presentation. To address questions of shaping what students think and how they think about it, I'm going to present three models. These models synthesize contemporary research on teaching and instructional psychology. Then, I'm going to use these models to suggest steps to take to promote cognitive achievements, as promised in my title. I'll wrap up my talk by offering a few suggestions about how these steps can be taken.

Models for Describing Instruction

I doubt anyone would claim that teaching and that learning from teaching are simple pursuits. To get a handle on complicated activities, however, it's often useful to consider simple versions of reality. Models are one form for such simplifications. Obviously, one model we should consider ought to describe what the teacher does while teaching. This model portrays instruction from the teacher's perspective. While teachers are teaching, students are doing something, too. Thus, we need a second model of what students do to learn from teaching. It should describe things from their point of view. These two models aren't sufficient however. We need yet a third model to describe how these first two fit together in the context of other features of instruction such as a curriculum and a social system that operates in the classroom. So, to describe instruction representatively, I will present three models, not merely one or two. This is as it should be--instruction is not simple. Too great an oversimplification of the complex reality of instruction is one of the reasons I believe we have not advanced as much as we would like in promoting cognitive achievements. I will speak more about simplifications versus oversimplications later. Now, I want to lay bare my assumptions about instruction. Then I'll describe the three models we'll need to address questions about what to teach it in promoting cognitive achievements.

Assumptions

Assumptions bridge the inevitable gap between an infinity of possibilities in theory and a limited set of particulars actually

dealt with in practice. They provide boundaries, setting off things that are considered from others that are ignored. I make three assumptions.

First, teachers and students are inherently cognitively active. Moreover, except for rare random perturbations in thought and genetically established reflexes, these cognitive activities are structured in patterns.

Second, I assume that learners pursue learning strategically and purposefully. This means that the cognitive activities that underlie learning are directed toward goals. This assumption doesn't contradict the fact that learners sometimes can't articulate what they have achieved or how they went about learning. What people learn sometimes can seem to themselves and often seems to observers to have been learned "unconsciously." Nonetheless, I assume that even in these cases, the cognitive activities that produced learning were strategic and purposeful.

Third, I assume that instruction is intentional. A teacher, or a surrogate for a teacher like a text or film, purposefully tries to determine what a student learns. This assumption doesn't deny the fact that students learn things unintended by the teacher. These learnings, however, do not result from instruction. Rather, they are the products of learners' inherent cognitive activity.

The first two assumptions characterize teachers and students as intelligent people who seek to achieve goals through action. The third assumption sets the stage for teaching to be ineffective. More specifically, whenever teachers' intentions go unfulfilled, instruction may not succeed. Arranging features of instruction to head off failure is a key to effective teaching. In order to make such arrangements, however, we need a directory of the features that comprise instruction. This directory is the model I will outline first. It provides a framework for fitting together the other two models I will present later to describe teaching and learning from teaching.

Facets of Instruction

The first model is based on research from the field of verbal learning. It describes instruction in terms of six facets: content, evaluation data, delivery of task cues, students' cognitive operations applied to acquire content and to retrieve content, and setting factors. First, I will describe each facet briefly. Then, I will demonstrate their interactive character.

Content. The information and motivations that teachers intend students to learn are content. There are three broad categories of content. The first category is knowledge. Knowledge can be subdivided further into two types. Declarative knowledge defines and

describes human experience. A definition of peninsula, an explanation for why a test was too hard, and an understanding of the periodic table of the elements are examples of declarative knowledge. The second type of knowledge is procedural knowledge. Procedural knowledge is a structure for action, for carrying out thinking or overt behavior. A heuristic for solving physics problems, a technique for coaxing a friend to help with homework, and a means for identifying essential information in a textbook chapter illustrate procedural knowledge.

The second category of content pertains to feelings and motivations. This type of content explains students choices among actions, and their vigor and persistence in pursuing those choices. Feelings of satisfaction and test anxiety illustrate this category of content. These are emotional reactions to past events and to events in the future.

The third category of content is called schemata. Schemata are complex, goal-oriented integrations of declarative and procedural knowledge and feelings. They are guides for taking action that delicately balance knowledge and motivation. Because their character is not found solely in the mere sum of their parts, schemata are accorded a separate category of content. As an example, when studying for an exam, a student's schema includes procedures for reviewing known material and its organization, and for checking how clear the material is. The schema also balances feelings about whether it is better to postpone telephoning a friend. As well, it includes hope for a good mark. It also contains criteria for deciding when fatigue makes further studying unprofitable, and more.

Evaluation data. This facet of instruction reflects the fact that students often receive feedback about their attempts to learn. Evaluation data always achieves meaning by a comparison either to an absolute standard or to a norm. The standard or the norm may be chosen by the student, as when a student sets a personal goal to achieve a mark of 85%. Or, the standard or norm may be imposed by the teacher. An example here is the case where teachers do or don't award partial credit. For students, the most obvious although not necessarily the most potent kinds of evaluation data are teachers' reactions in class and the scores received on tests and assignments.

Delivery of task cues. When students try to acquire or retrieve content they have a task to accomplish. In setting these tasks, teachers try to guide students' thinking by providing cues about how students might cognitively work on content. Two examples of cues teachers often use to shape students' cognitions are telling students to look for similarities between two concepts and starring particular bits of knowledge written on the chalkboard. Since cues like these are intended to help students acquire new knowledge, they can be labeled acquisition cues.

Correspondingly, there also are cues teachers deliver to shape students' cognitions directed to retrieving information. An example of a retrieval cue would be a teacher's admonition to "think hard" before answering a question. Presumably, this signals to students that they shouldn't necessarily be satisfied with a first or seemingly obvious answer. Instead, students should search their memories deeply before answering.

Acquisition cues and retrieval cues also appear in textbooks. Margin headings are intended to steer students toward acquiring a particular structure of content. Italics invite students to spend extra effort to acquire particular concepts. And questions inserted in text ask students to practice retrieving content in particular ways. Thus, the delivery facet concerns attempts by a teacher, text, or film to engage students in particular types of thinking about content to learn it and to retrieve it.

Acquisition operations. Students don't learn content by osmosis. Students acquire content by cognitively working with it and on it. To do this, they almost always activate related information that was learned previously. Sometimes, they may translate words into mental images or vice versa. Also, they may rehearse new content, create categories for bits of content, and monitor the products that result from these cognitive operations (Winne, 1984). These kinds of cognitive operations make up another facet of instruction, the facet concerned with thinking to learn content.

Retrieval operations. To find out what students have acquired, the teacher or the students themselves create occasions for students to retrieve content that was supposed to have been acquired. To do this mental work, students engage retrieval operations. These are the complement of acquisition operations. Retrieval operations are the means by which students bring content out of their cognitive storehouse to accomplish tasks like supporting the learning of new related information or answering test items. Mentally asking what is similar to a term in a question, or categorizing information and then searching for other content in this category are examples of retrieval operations.

Setting variables. Instruction always takes place in a social and cultural milieu. In classrooms, a large part of this milieu is structured by the teacher. This is done through rules for classroom management, a system governing rewards for students' scholastic and personal achievements, and routines for frequent activities like taking tests, boardwork, or science labs. Students, too, shape this milieu by choosing friends and models, by declaring their values, and even by their physical health. Thus, general but usually flexible conditions are established within which instruction takes place. These conditions are setting factors.

Summary. These six facets make up a directory for describing instruction. The directory can be titled by an acronymn that uses

the first letter of each facet: CEDARS. My brief descriptions of these facets barely hint at the true nature of instruction because I described each facet independently. Common sense and reams of research stress the fact that the facets interact. I can describe these interactions best by focusing microscopically on an example of one instructional act. At the same time, I'll develop the other two models needed to describe teaching and learning from teaching, respectively.

Models of Teaching and of Learning from Teaching

An example. Suppose Mr. Jones just asked his class, "How can we solve for X in a quadratic equation?" Jim replies, "By graphing." Mary chimes in, "By using the formula." Then Mr. Jones responds enthusiastically, "Right, Jim! And Mary, what's the formula?" Why did Mr. Jones do this?

Mr. Jones' praise of Jim's answer is both evaluation data and a cue he delivered to stimulate other students' cognitive processing. The evaluation datum marks Jim's answer as correct. But this mark also must involve other students in thinking about content if they are to learn that graphing is one method for solving quadratic equations. How should students think upon delivery of this acquisition cue?

Similarly, Mr. Jones' prompt for Mary to provide the formula also spans the delivery and evaluation facets. As an evaluation datum, Mr. Jones intends that his prompting question signals to Mary, and to the other students, that Mary's answer is not up to a standard. Mary didn't give a complete answer--she left out the formula. As well, the teacher's prompt is a cue for students to respond cognitively to this instructional interchange made up of a question, Mary's answer, and the prompting question. Can you guess the cognitions Mr. Jones is cuing? Can the students? I will describe two models that frame answers to these kinds of questions. But first, let's return to the CEDARS model momentarily.

Who determines what? In terms of the CEDARS model, the teacher and students exercise varying degrees of control over each of the facets. The content facet and the delivery facet are mostly controlled by the teacher. For example, if the teacher chooses not to present graphing as a method for solving quadratics, this content won't be part of instruction unless a knowledgeable student like Jim divulges it in class. Similarly, in most classrooms, the teacher determines most of the cues delivered during teaching that are signals to students about thinking. However, students also deliver cues that can guide cognition. Remarks like, "That formula seems really important to remember" can function as acquisition cues. As well, teachers are almost solely in control of externally provided evaluation data that refer to declarative and procedural knowledge. On the other hand, students control most of what works as evaluation

data for motivations. Teachers and students share control of evaluation data for schema.

Features of the setting facet are very much jointly determined by the teacher and the students. Although the pace of teaching starts out to be teacher determined, students almost always influence pace by looking puzzled, asking questions, or nodding in agreement as the teacher talks. While the teacher can define rules for handing out grades, students may treat these rules as a competitive system or an individual one. As a last example, the climate of a class--its openness, supportiveness, and so on--is clearly influenced by all the participants.

The remaining two facets, the complementary cognitive operations that students engage to acquire content and to retrieve content, are mostly under each student's control. A student decides whether to pay attention or to rehearse a formula. How students think when acquiring and retrieving content is central in determining what they learn. In other words, students cognitively mediate the impact that teaching has on what they learn. By planfully manipulating cues in the delivery facet, and influencing features in the content, evaluation, and setting facets, Mr. Jones tries to shape students' cognitive mediations of instruction. In general, to be successful, a teacher must intentionally influence students' cognitive activities in lessons. But the teacher cannot control these cognitive activities directly--students cognitively mediate the effects of Mr. Jones' teaching. Let's return to Mr. Jones' algebra class to develop a model of students' cognitive mediations of teaching.

A cognitive mediational model of teaching. The degree of correspondence between each student's cognitive mediations of Mr. Jones' cues and his intentions for students' cognitive activities determines how effective instruction will be. At least four separate conditions must be met if this correspondence is to be achieved.

First, in order for Mr. Jones' cues to function at all, students must attend to them. Those who don't listen to Mr. Jones praise Jim and prompt Mary obviously can't be influenced to shape their cognitive operations as he intends.

Second, students must correctly perceive Mr. Jones' intentions behind his cues. If, for example, students don't understand that Mr. Jones wants them to rehearse Jim's answer when he praises it, this cue won't function to help students acquire the content that quadratics can be solved by graphing. Or, if students don't perceive that Mr. Jones wants them to add to their schema a routine that elaborates answers when a formula is involved, then his prompting of Mary's answer won't teach what he means by complete retrieval of content. Thus, students need to perceive cues correctly for teaching to work.

Third, students who attend to and perceive Mr. Jones' two cues must be capable of carrying out the cognitive operations to yield the two cognitive products Mr. Jones seeks for them to create. If students can't remember all the terms in the equation when Mary answers, they won't be able to rehearse the content or feel pleased about acquiring it when Mr. Jones praises Mary.

Finally, even if students attend to, perceive, and are capable of carrying out the cognitions Mr. Jones intends by delivering these particular cues, some simply may choose not to do it. These students lack motivation to mediate instruction as the teacher intends. Instruction won't be successful for these students.

A central feature of everyday teaching highlighted by the cognitive mediational model is that students have cognitive tasks to accomplish as they try to learn from teaching. This suggests a third lens for viewing lessons. I turn next to a model of learning from teaching that provides this perspective.

Student tasks in learning from teaching. Students in classrooms have jobs to do. From their vantage point, they are responsible for decoding instructional cues and cognitively manipulating content to achieve mastery of the curriculum. As described earlier, content encompasses more than merely the declarative and procedural knowledge in a subject area. Students also are expected to develop self-reliance, to coordinate their wants with the rules of school's society, to build interest, and much more. Moreover, students are supposed to acquire schema to guide complicated thinking and behavior involved in problem solving, designing and completing projects, and so on. All these acquisitions are cognitive achievements that result when students engage in and successfully complete tasks.

A task is something that the student must do. Answering a teacher's question, planning a session to study for an exam, and sustaining self-concept are tasks. Tasks are bounded by a set of initial conditions and a goal. Tasks are worked through step by step according to cognitive plans. Some aspects of tasks are determined by variables in the facets of instruction over which the student has minimal control. For example, Mr. Jones determines whether students will work out equations with or without opportunities to look back at the book. This variable comes from the setting facet. Also, Mr. Jones determines how the task is introduced. For instance, he might intend to prime students' memories either by a demonstration or by providing only a verbal explanation of what to do. As well, Mr. Jones defines some of the standards by which students' work on the task will be judged, a variable from the evaluation facet. Here, for example, he may or may not award credit for partially correct answers.

Other features of the initial conditions, the goal, and the dynamics of accomplishing tasks are mostly determined by students. For instance, students may be motivated to persist at solving equa-

tions even when they encounter difficulty. This variable describes a motivational aspect of their acquisition and retrieval operations. Turning to the evaluation facet, some students may feel good that they are persistent because this proves to them that they're trying hard. Other students, however, may evaluate their felt need to persist as an indicator of their ability. For them, taking a long time only proves they aren't smart.

A distinguishing feature of tasks is that students use plans to carry out tasks. Plans are organized arrangements of schemata that students use to accomplish tasks. Plans typically follow a general sequence like this: (1) Compare the current status of cognitive accomplishment with the goal. Quit if these match within some tolerance of the standard or norm that applies to this task. If the current status is below the tolerance allowed, try to characterize the differences to learn something about what needs to be done next. (2) Activate knowledge, motivations, and schema that, according to the plan being followed, have some potential to reach the goal. Use these to operate on the cognitive products that make up the current status. Also, find new content from either memory or the external environment (a friend, stuff on the chalkboard) that can help. (3) Recycle to the first step.

This cycle for carrying out plans to accomplish tasks is called a test-operate-test-exit unit or TOTE. Two tacit aspects of cognitive activities like TOTE's merit explicit mention. First, the goal for any single task is multidimensional. Alternatively, it could be said that there are many goals for any given task. Students approach tasks not merely to satisfy teachers' intentions about instructional objectives. Inherent in tasks are students' feelings about themselves and the topics they are learning about, as well as opportunities to practice and adapt schemata. Although a task like learning from a demonstration sometimes may seem to focus only on one particular item of content, say a procedure for graphing quadratic equations, it inevitably involves all three categories of content.

The second tacit feature of tasks is that they are jointly produced by a teacher and a student. Tasks are mediated cognitively by students. Students translate tasks teachers pose into personal cognitive representations via cognitive mediations of instruction. The initial conditions and the goal that bound a plan for accomplishing school tasks depend on students' attention, perception, capabilities, and motivation. Thus, tasks that students pursue in school are inherently "their own" in every respect.

Consolidating the Models

These three models--the CEDARS model, the cognitive mediational model of how teaching can impact learning, and the task model of how students learn from teaching--describe instruction from three different but interrelated vantage points. These brief sketches also

capture two major aspects of contemporary research in instructional psychology. The first is that instruction is riddled with interactions. Although I omitted descriptions of hosts of such interactions researched in instructional psychology, the message is clear: a representation of instruction that is ecologically valid will not be simplistic. Because these three models blend together in ways that point to interactions, they begin to lessen the distance between abstract research and accounts of idiosyncratic, real, everyday instructional events.

The second feature of my multi-model approach is that it blends together empirical research and theory from many traditions. For instance, instructional objectives are linked to motivation by way of students' cognitive renderings of goals for the tasks they pursue during lessons. Also, structural designs for content are linked to teaching skills via the conditioning factors of students' attention, perception, capability, and motivation in the cognitive mediational model.

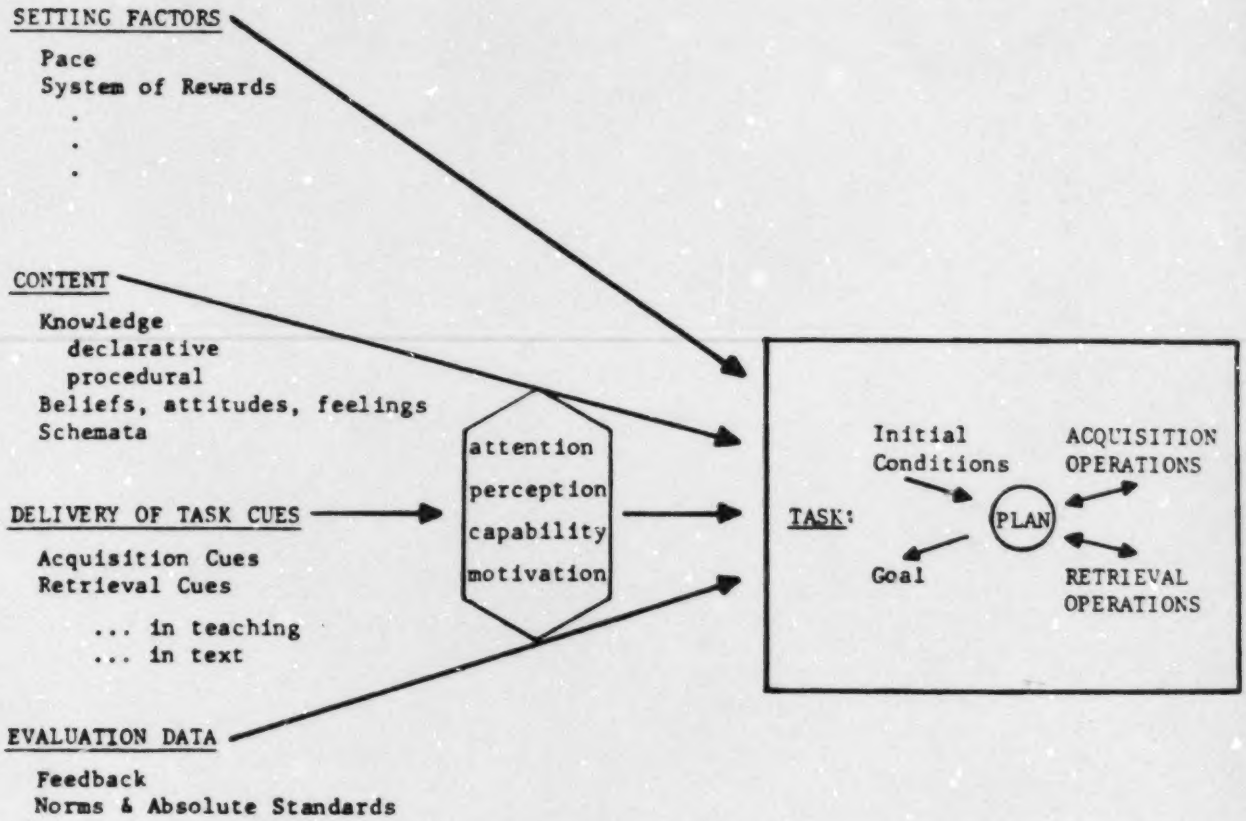
Summary and Forecast

To this point, I have presented a set of three assumptions that set off my view of instruction from hosts of others and three models that describe instruction per se. The assumptions are: (1) cognitive activity is inherent and patterned; (2) learning is a goal-oriented cognitive activity; and (3) instruction is an intentional activity where teachers intend to influence students' learning.

I have attempted to diagram the three models and the ways they relate to one another in the accompanying figure. One model, the cognitive mediational model, elaborates the dynamics of my third assumption regarding the intentional aspect of instruction. It identifies four separate ways that teachers' attempts to guide students' cognition can be foiled. Specifically, if teachers are to realize their intentions, students must succeed at: (1) attending to cues about cognition; (2) correctly perceiving the nature of cognitive work that the teacher intends to be engaged; (3) having available the resources needed to carry out cognition capably; and (4) being motivated to accomplish these cognitive activities.

A second model, the task model of how students pursue learning from teaching, sketches the dynamics of instruction from the students' point of view. This model describes three interlocking features of learning as a task: (1) the information available when the task is presented initially; (2) the goal toward which students are to work; and (3) cognitive plans that assemble resources and coordinate students' cognitive attempts to reach the goal from their initial condition.

The third model, CEDARS, identifies facets of instruction within which the preceding two action-oriented models are lodged. CEDARS


SETTING FACTORS
Pace
System of Rewards
CONTENT
Knowledge
declarative
procedural
Beliefs, attitudes, feelings
Schemata
DELIVERY OF TASK CUES
Acquisition Cues
Retrieval Cues
... in teaching
... in text
EVALUATION DATA
Feedback
Norms & Absolute Standards
attention
perception
capability
motivation
TASK:
Initial Conditions
PLAN
Goal
ACQUISITION OPERATIONS
RETRIEVAL OPERATIONS

is an acronymn for content, evaluation data, delivery of cues, acquisition operations, retrieval operations, and setting factors. This model functions like a checklist. When planning for teaching and when analyzing teaching effects, information about each facet is needed to put together a complete picture of what happened. Moreover, as shown in my example of Mr. Jones' teaching, interactions across facets are the sparks that animate the CEDARS model. Interactions are the proper focus, not just each separate facet.

So much for assumptions and models. How can we use these to promote cognitive achievements? The forecast of an answer is seductively simple. Like everything else so far, it has three parts. First, make sure that teachers' intentions for students' cognition are realized. Do this by insuring that students succeed at attending to delivery cues, at correctly perceiving the cognitions teachers intend them to activate, at having necessary resources so they have the capability to succeed, and at being motivated. Second, support students as they pursue tasks. Do this by insuring that the task can be accomplished given its initial conditions, that the goal of the task is perfectly clear, and that students have a cognitive plan that will work. Third, coordinate these two activities across all the facets of instruction. Do this by insuring that what happens in one facet does not interfere with the events occurring in any other facet. Better yet, make the interactions among facets synergistic, dynamically supportive of one another.

Let's explore in more detail how this answer might take shape in reality.

Promoting Cognitive Achievements

In this second section of the talk, I'm going to describe some ways of teaching that can promote cognitive achievements. But before I go on, I'm obligated to point out clearly that what I'm about to describe is as much an agenda for future research as it is a synthesis of select contemporary scientific knowledge about instruction. I admit up front that answers aren't yet available to our most central questions about how to enhance teaching and learning. But we all know that. What I do claim, without hesitation, is that we now have means to approach truly significant improvements in schooling. Like any other change in human affairs, this will take time. Inevitably, it will show some zig-zagging around an ideal path to improvement. I'll have more to say on this at the end of my talk. Now, however, with these caveats in mind, let's set aside these issues and return to the domain of instructional psychology.

Steps Toward Realizing Instructional Intentions

According to the cognitive mediational model, four cognitive factors determine whether students will respond cognitively to their

teacher's delivery of acquisition cues and retrieval cues. These factors are students' attention, perception, capability, and motivation. What sorts of steps can be taken to increase the chances that students succeed at each of these cognitive achievements? A general answer to this question is fairly straightforward: teach students about the cognitive work that corresponds to instructional cues. I'll treat each of the four factors in turn.

Gaining Attention

Cues that teachers and texts deliver to students may not always be noticed. Occasionally, cues that students know about are actively ignored. For example, how many students pay attention to the various levels of headings when reading textbooks? Headings are acquisition cues. During classroom teaching, do students pay attention to teachers' cues that provide similar information about how content is organized? For instance, are overviews that teachers sometimes give at the beginning of lessons attended to, or are students otherwise busy getting out a book or finding last night's homework?

Three key things probably determine whether students attend to cues. First, they may need to be told that particular teaching behaviors and features of text are cues to use particular cognitive operations. Second, students need to be undistracted by other events in order to pay attention to an instructional cue. If other pursuits, like having the answers ready from last night's homework on quadratic equations, are more important for avoiding criticism than is listening to an overview that the teacher is presenting right now, then we shouldn't expect students will pay attention to some cues. Third, teachers need to teach in ways that help to make cues salient. Slowing down, pausing slightly before and after cuing, modulating pitch and loudness of the voice or color of the chalk may help.

Clarifying Perceptions

There is much evidence that students don't always accurately perceive what form of cognitive work to do after they've attended to an instructional cue. Consider one of the cues prominently written about--teacher praise. After a student has answered a question or performed a task, a teacher might react, "Well done, Mary." What cognitive work is Mary supposed to do now: attribute her success to effort, rehearse the content she just spoke, conclude that this topic can be rewarding? Moreover, what cognitive operations does the teacher intend the other students to engage when they supposedly listen to this interchange?

As another example, how should students react cognitively to the very common cue delivered in textbooks of questions inserted within or between paragraphs? One possibility is to try to retrieve an answer. Another is simply to do a superficial mental check to see

whether concepts mentioned in the question make sense or are still available in memory. Yet a third possibility is to forget trying to answer the question and go back in the text to find one.

When there are alternative perceptions about how to respond to instructional cues, it is likely that some students won't engage cognitive operations that teachers or authors of text intend. Also, students sometimes are so active in seeking cues about how to learn from teaching that they attend to and perceive an instructional cue that their teacher did not provide intentionally. In other words, some students' perceptions of instructional cues are "immaculately conceived"--students judge they have been cued to do certain kinds of mental work when the teacher intended no such thing.

Lots of research has shown that students can be trained to perceive teachers' and authors' messages about which cognitive operations to use in response to different instructional cues. Providing training like this seems to be the obvious answer to students' problems of unclear perceptions about instructional cues. Such training should focus on the procedural knowledge and schemata that make up plans students use to accomplish classroom tasks. I'll have more to say about this later when I describe steps to take to facilitate tasks.

Maximizing Capability

Let's assume that a student has attended to an instructional cue and correctly perceives the nature of cognitive activity, that is, the plan that's appropriate for the task at hand. Knowing how to operate cognitively on content doesn't guarantee that the student will be capable of succeeding. The teacher must take steps to insure that students are capable of performing the operations necessary to succeed at instructional tasks.

In general, there are two conditions to which teachers should attend to maximize students' capabilities to succeed at cognitively mediating instructional cues. The first condition is that students, like everyone else, are limited in the amount of information that they can handle. Care must be taken not to overload the limited capacity of the cognitive processing system. One way to avoid overloading the system is to design instruction so that the students are not doing more than one or two tasks at a time. For instance, the teacher who asks a tough question and then turns to write some new content on the chalkboard during the ensuing silence invites students to overload their memorial capacities.

Another technique that can help to reduce the strain on students' cognitive systems is to chunk together similar bits of content. If our Mr. Jones is working out a quadratic inequality on the chalkboard, that is, demonstrating procedural knowledge, he may be asking students to work on too many chunks of content if he also

asks students for definitions of terms associated with quadratics such as discriminant and leading coefficient that are declarative knowledge.

The second condition that bears on students' capabilities to mediate instruction is the degree to which students have practiced the task. Instructional psychologists have demonstrated many times that students have a greater chance to succeed at learning when they can execute cognitive operations automatically. The way to enhance automaticity is to drill. Drill doesn't have to yield rote, non-meaningful learning. Non-meaningfulness is a property of what students learn, not how they acquire and retrieve it. So, in the case of students' cognitive mediations of instructional cues, teachers need to do more than tell students to perceive cues accurately. Teachers also need to provide students with extensive practice to make links between cues and associated cognitive operations automatic.

Motivating Cognitive Work

When teachers ask students to mediate cues, students have to do cognitive work. Just because students know when to do what and are capable doesn't guarantee that they'll "bother" to follow the guidance teachers offer by instructional cues. Students need to be motivated. I can outline several techniques for motivating students in the abstract. Obviously, teachers will need to personalize these suggestions.

First, if students don't know what outcome to expect when they engage in cognitively mediating instructional cues, it's not likely that they'll be motivated. Unpredictability can mean risk, and risks are often dealt with most comfortably by avoiding situations like asking questions or offering opinions. Communicating to students what outcome expectations apply in cognitively mediating instructional cues is one component in motivating students.

Knowing the likely outcomes of different instructional tasks isn't enough to motivate students, though. Students also need to believe that they are likely to succeed at accomplishing acquisition and retrieval tasks to which instructional cues refer. If students have low expectations about their efficacy, they probably won't be motivated to engage in the cognitive work teachers outline. What can teachers do to increase students' efficacy expectations? Probably the most beneficial thing is to insure that students are solidly drilled in plans for accomplishing tasks. Expectations for completing a new task almost always are high when the new task is like one that's been completed successfully many times before. Introducing a new task by pointing out similarities between it and prior tasks, and making sure that students have been successful on the previous tasks is a good method for raising efficacy expectations.

There is yet one more important dimension to motivating students. Suppose that a student knows the outcomes to expect for succeeding and for failing at a task. Suppose further that this student has a very positive expectation about being able to do what the teacher asks. Will the student be highly motivated? Not necessarily. Students, like others, attribute their successes and failures to different sources. For instance, success at a task might be attributed to luck or extra effort or an especially easy task. Failure might be attributed to being stupid, not working hard or long enough, or an especially hard task. Some attributions, like failing because of low ability, are not motivating. Attributions like succeeding because the task was so easy that anyone at all could do it aren't motivating either. In general, teachers can help motivate students by insuring that students make appropriate attributions for successes and failures. Do not "butter them up" by telling students they can do anything if only they'll try hard enough. Do tell them honestly why they succeeded or failed. And, whenever appropriate, focus students' attributions for their failures on sources that are under their control.

Summary

This finishes my set of suggestions that derive from the cognitive mediational model. Here, then, are steps, point by point, that teachers can take to improve students' cognitive mediations of instructional cues.

STEP 1 Tell students what instructional cues are used.

STEP 2 Structure presentations so that only one cue is delivered at a time.

STEP 3 Make instructional cues stand out.

STEP 4 Train students to know which procedural knowledge and schemata to match with acquisition cues and retrieval cues.

STEP 5 Avoid overloading cognitive capacity: present one task at a time and chunk similar content.

STEP 6 Drill students so that cognitive mediations of instructional cues become automatic.

STEP 7 Tell students explicitly what outcomes to expect when cognitively mediating instructional cues.

STEP 8 Maximize students' efficacy expectations by telling them how new tasks are like previous ones at which they have succeeded.

STEP 9 Make explicit the sources to which students should attribute their successes and failures at tasks.

Steps Toward Facilitating Instructional Tasks

Earlier, I described a model of how students approach learning from instruction. It characterized learning as a task. To carry out learning tasks, students activate cognitive plans to work on a set of initial conditions, transforming and adding to these conditions to achieve multiple goals. When our Mr. Jones asked, "How can we solve for X in a quadratic equation?", he set a fairly uncomplicated task. The initial conditions here are the topic, namely, methods for solving a particular form of equation and a request for students to respond. Superficially, the goal appeared to be to name members in a category of such methods. But as we saw, Mr. Jones applied criteria for achieving the goal that went beyond merely naming methods of solution. He also prompted Mary to present the quadratic formula in addition to naming this technique.

To accomplish tasks like this--or others like preparing a report about a chemistry lab, studying for a test, taking good notes, and having a productive discussion--students need content knowledge. In particular, they need to comprehend both the initial conditions and the goals that bound the task. Then they require schemata that can be activated as plans for carrying out tasks. I'll address each of these three features of tasks in turn.

Comprehending Initial Conditions

There are two types of content that students need to master before they can comprehend the initial conditions of a learning task. I already have spoken extensively about one of these, namely, the guidance that teachers intend to provide for students by delivering instructional cues. If students can't use instructional cues, then an important part of the initial conditions of school tasks will be missed. My message here is simple: to promote cognitive achievement, take the nine steps just described.

The other type of content students have to understand to comprehend the initial conditions of a task is declarative knowledge about what the task is. If I ask you to instrumentally condition students to shadow text, do you have any idea what task I've set? I doubt it. While it seems so obvious as to approach the trivial that students need to know what the task really is, how many 10th grade students really comprehend tasks like these: prove a theorem in geometry; analyze a hypothesis in science; interpret the meaning in a poem; program a sorting procedure for your computer; or characterize a policy of a government? Students need to know what the task is and

what they already know about it before tackling the task itself. This is what I mean by comprehending a task's initial conditions.

Comprehending the Goal

All tasks have goals. As I described earlier, tasks almost always have multiple goals that relate to the three categories of knowledge, motivation, and schemata. Students need to comprehend what goals are set for tasks during instruction. There are at least two significant reasons for this. The first is that a student's understanding of goals is a major determinant of the cognitive plan that is activated to pursue a task and of the criteria used to monitor how the plan progresses. I'm sure you're all familiar with students' constant desire to know when they'll be tested on material they read. The reason for this incessant clamoring is not only to avoid low marks. Students use different cognitive plans when they read text for a quiz tomorrow than when they expect only to have to be conversant with the content. In particular, they rehearse more frequently and they rehearse different content in reading for a quiz. Thus, the way students comprehend the goal affects how they cognitively work on content.

The second reason students need to comprehend the goals of a task is motivational. If students are not clear about goals, motivation likely will be low. This is because it is not clear what outcome to expect for effort that has to be devoted toward accomplishing the task. A good illustration of this phenomenon can be seen when students ask, "Why do we have to learn about quadratic equations?" The same notion applies to the clarity of goals in history, grammar, meteorology, and programming logic. Without clear expectations about the goals of these tasks, it's not clear why they should be worked on.

The remedy for poor comprehension of goals for a task is much like that for initial conditions. Students need to know what the goals are for each task they undertake. Moreover, they want to know what consequences to expect for their efforts. Both these kinds of knowledge are declarative. Hence, students should be told what the goals of tasks are before inviting them to work on tasks per se.

Having Plans

Given that a student comprehends the initial conditions and the goals of a task, what remains is to engage cognitive plans to transform the initial conditions into the goal. Cognitive plans are sometimes simple, but most often, they are complex. As is true of all the other kinds of knowledge, the schema that underlie cognitive plans can be taught directly. Teaching students plans for accomplishing instructional tasks has become a prominent area of research

in the last half-dozen years. What has been learned from this research can be summarized very tersely as follows.

First, plans involve several steps. Each step needs to be taught to the point that it is easy to carry out. In other words, each step of the plan should become automatic. This degree of mastery is necessary so that students can devote their cognitive resources to operating on content according to steps in the plan rather than figuring out how to work out steps in the first place.

Second, students need to see how the steps in the plan or how the plan as a whole can be used to approach goals of tasks. If part of a plan calls for students to identify significant features of some concept, they might be shown how this same step also will help them when they write essay answers. Identifying significant features of a concept during acquisition in class isolates these for rehearsal. Identifying significant features of a concept during retrieval in an essay test item elaborates answers in ways likely to earn more points. Coordinating acquisition operations and retrieval operations like this is valuable.

Third, students can't learn plans or become proficient in using them without practice and feedback that focuses on the plan rather than a curriculum area. For instance, suppose one step in a plan for reading science text for comprehension is using prior knowledge to interpret new content. Here, a student might mentally pause after reading each paragraph to compose an analogy between the content in the paragraph and prior knowledge. If the paragraph described how the shape of coastlines influences tidal volume, an analogy might be drawn to the topography of land masses and wind currents. Students need practice in composing analogies like this and feedback to help them determine how good their analogies are.

To provide feedback, teachers need hard copies or traces of these mental analogies, perhaps obtained by having students record several analogies per reading assignment. In general, traces should provide clear evidence about which cognitive activities were practiced by students and whether they were practiced at all. Traces also are essential as a basis for providing evaluation data about the quality of the student's cognitive achievements. Thus, traces of students' cognitions for teachers go hand in hand with practice and feedback about plans for students.

Summary

Tasks are the means by which students attain cognitive achievements. To increase students' proficiency at carrying out instructional tasks, teachers need to take steps to help students comprehend the initial conditions and the goals that set boundaries around tasks. As well, teachers need to prepare students to engage in tasks

by teaching cognitive plans. Here, point by point, are steps teachers can take to facilitate students' accomplishment of instructional tasks.

STEP 10 Teach declarative knowledge used to set a task before assigning the task.

STEP 11 Teach declarative knowledge about the goals of a task.

STEP 12 Teach students the plans they need to accomplish tasks.

STEP 13 Make students capable of carrying out each step in a plan automatically.

STEP 14 Teach the general utility of each step of a plan and of the plan as a whole.

STEP 15 Obtain traces of the products of steps in a plan to insure that students practice steps and to provide a medium for evaluation data.

Recapitulation About Cognitive Achievements

In the preceding moments, I've sketched a series of 15 steps that teachers can take to promote forms of students' cognition. Each step has been targeted at affecting what happens during instruction, when teachers are teaching and when students are trying to learn. Cognitive achievements of the kinds I've been describing that are attained during lessons are what make teaching effective or ineffective. If students can reach these cognitive achievements, during instruction, then I believe we will have made substantial strides toward improving the overall quality of education. But I have yet a few more steps to add to this list before I finish this talk. These last few steps address means by which teachers may be helped to take the preceding 15 steps.

Steps Toward Taking Steps: A Beginning for Change

At several points in this presentation, I've made note that there are difficulties that will impede taking the steps I advocate or that make the steps themselves tentative rather than sure-footed. Before closing, I want to patch up a portion of these issues as I promised I would in my introduction.

I do not delude myself with false hopes that you can return to your schools to put in place the steps I've outlined today. At the beginning of this talk, I asserted that instruction is not simple.

I'm sure you'll agree that the theoretical content I sketched in the first half of the talk is not simple either. But it is essential to sketch these models to provide structure and reason for the steps I outlined to promote cognitive achievements. In reality, the three models I described are schemata that teachers can acquire and use as plans to guide their instruction. It is my firm belief, a belief based on teaching these schemata to undergraduates in a course and on the research about pre- and inservice teacher education efforts, that piecemeal workshops will not suffice to teach these schemata to teachers. A long-term concerted effort is what's needed. Hence, the place to begin implementing what I advocated today is in teacher education programs. Teachers, just like students,need to reach levels of application that are automatic. This requires lots of drill, supplemented by extensive evaluation. Just as much care will be needed to design instruction for teachers as is needed for public school students.

In the opening to the second half of this talk I specified that my suggestions pointed to needed research in the future just as much as they synthesized what is already known. There is an important message in the fact that I can't provide unequivocal answers to resolve the dilemmas faced in today's educational system. The message is <u>not</u> that research is fairly useless, something to be called on to make impressive rhetoric and shunned in practice. Experience and good will, by themselves, aren't adequate either. If they were, the millions of hours logged by practicing teachers already should have provided almost all the solutions for which we are searching today. Rather, we need to encourage <u>good</u> research. Teachers, students, and professional researchers need to work together to create the knowledge we need. And school systems need to be not merely receptive, but active initiators of research.

In summary, then, here are two more steps that need to be taken in order to promote public school students' cognitive achievements.

STEP 16 Revamp teacher education curricula to include features corresponding to Steps 1-15.

STEP 17 Do research, either on your own or in collaboration with professional researchers.